

# Omnisafe

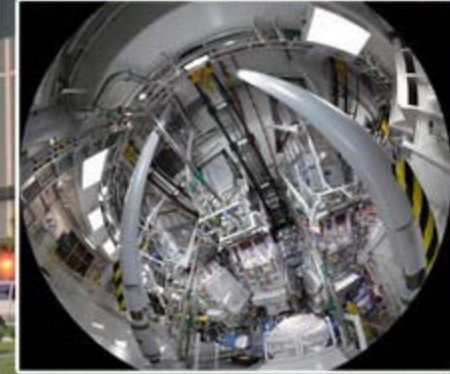
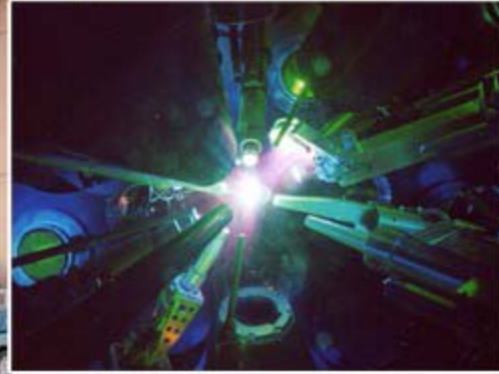
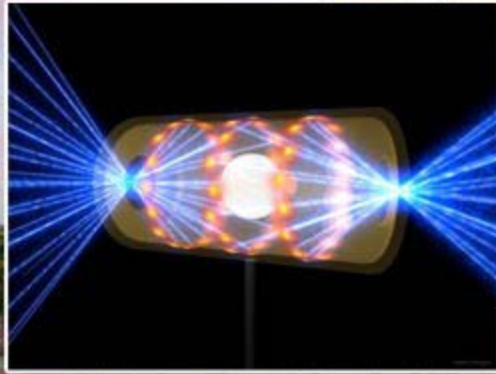
*High Performance*

**Metal Face Seal,  
Multi Mate – Demate,  
Torque Elimination Fittings**

Promoting Gas Handling Safety and Purity

[www.omnisafe.net](http://www.omnisafe.net)

# Nuclear Reactor Applications

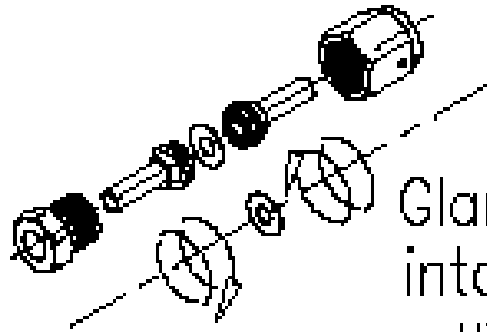


## NIF Laser

1. **System modularity, flexibility**
2. **Subsystem or instrument test**
3. **Electrical and thermal failures of components due to close proximity welding**
4. **Component replacement due to failure or upgrade**
5. **Cost reduction**
6. **Expedited Schedule**
7. **Weldability, fittings allow purge and inspection of closed loop system welds.**
8. **Can withstand transportation shock and vibration.**

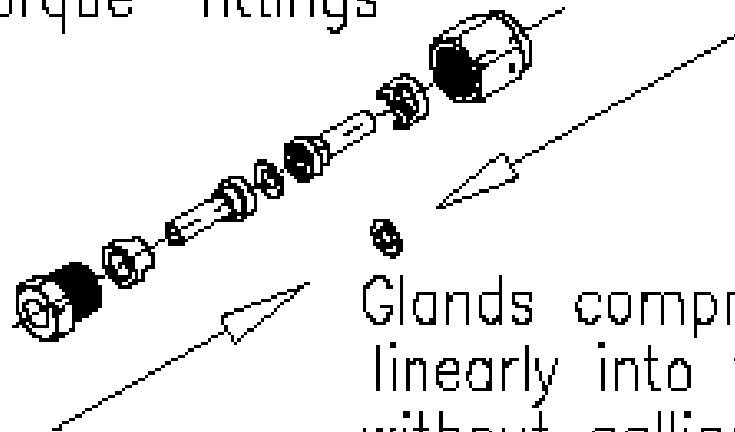
# How does it work?

"VCR type" fittings



Glands rotate  
into the gasket  
galling both surfaces.

Omnisafe "Anti torque" fittings



Glands compress  
linearly into the gasket  
without galling.

## Economic Justification for the OmniSafe

*By associating features with benefits we are able to demonstrate how the OmniSafe fitting enhances product quality and reduces the cost of ownership for semiconductor process equipment.*

### Features

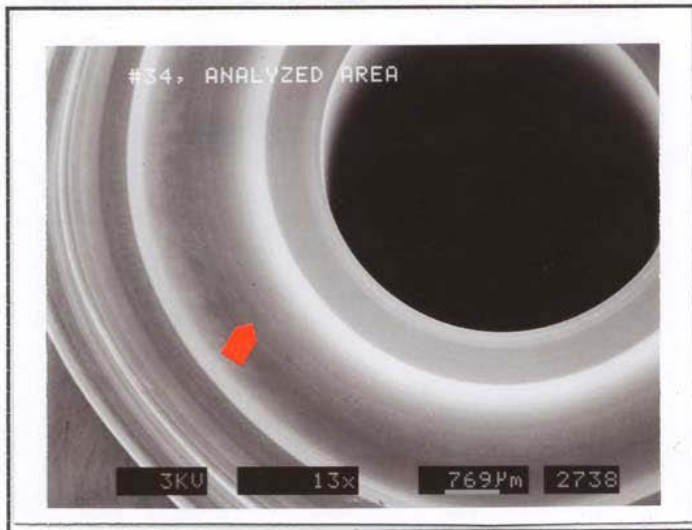
### Benefits

1. No gland/component rotation during make up.	Decreased installation time, perfect component alignment.
2. No stored "residual torque", as nuts tighten the glands twist, a preload is set in.	No additional tube and component clamps to prevent component loosening.
3. No particles from glands and gasket.	Less system pump down and purge time.
4. No galling of sealing surfaces	Reduced scrap, extend component life, less down time @ \$50k/shift , lower warranty cost.
5. Preserves the chromium enriched surface area on sealing surfaces.	Protects the surface from corrosive attack, extends component life.
6. No "cross torquing", a loosening caused by torque from adjacent nuts being tightened.	Shorter repair time, more reliable maintenance. Reduced employee frustration.
7. No loosening due to vibration, thermal cycling, or component rotation.	Higher yield, reduced maintenance cost, shorter tool installation time. Critical on corrosive, pyrophoric, and toxic lines. Reduced warranty cost.
8. Glands and gaskets are compatible with existing fittings.	Standard gaskets fittings.
9. Fitting is the same size as standard when assembled.	No system redesign necessary. May be installed with standard wrenches
10. Torque suppressors prevent gland bead to bead contact.	No gland self destruction if fitting is tightened when gasket is sheared or missing. Less repair/maintenance.
11. May safely tighten 1/4th turn past finger tight.	Less time to pass leak check, reduced maintenance cost due to seal failure. Reduced training time for technicians.



Standard Metal Face Seal Fitting (Gland),  
14 Times Magnification

These S.E.M.s show the galling of the crown of the torroid (red arrow) on a gland of a legacy metal face seal fitting (top view) after one mate with a nickel gasket. This torroidal galling is the source seal degradation and of particles in the 0.5 to .01 micron size range.



Omnisafe Anti Torque (Gland),  
13 Times Magnification

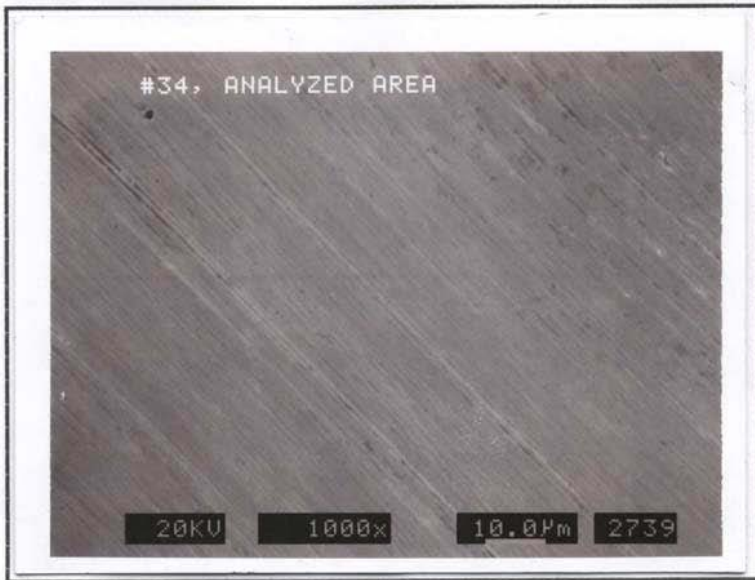
The Omnisafe gland (bottom view) shows no galling after one mate with a nickel gasket. Pure compression, without rotation, does not cause galling of sealing surfaces.

## Single Make-Up, 1/8th Turn Past Finger Tight



Standard Metal Face Seal Fitting (Gland),  
1000 Times Magnification

Under the highest magnification, these S.E.M.s show the source of the 0.5 to 0.1 micron particles on a gland of a legacy metal face seal fitting (top view) after compression with rotation against a nickel gasket.



Omnisafe Anti Torque (Gland),  
1000 Times Magnification

The Omnisafe gland (bottom view) shows benefits of torque elimination, no galling or particle generation.



Standard Metal Face Seal Fitting (Gland),  
200 Times Magnification

After 25 mate/demate cycles the repeated galling of the SS316L gland prevented the fitting from passing the 10-9 (atm cc/sec He) leak check spec.

This galling problem is much worse with glands of softer alloys like monel, inconel or nickel.



Standard Metal Face Seal Fitting (Gland),  
1000 Times Magnification

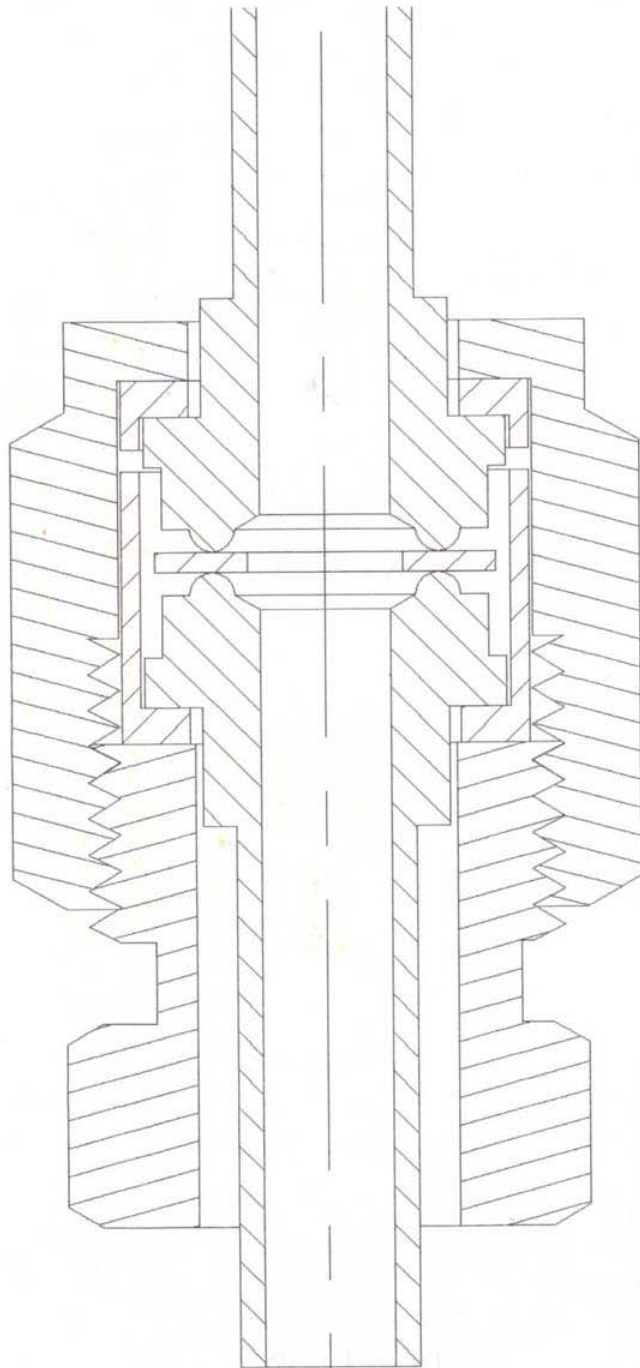
In later field testing, at Lawrence Livermore National Labs [3], an Omnisafe fitting was still operational and passed leak check after 1557 mate/demate cycles over a 6 year service period.



Omnisafe Anti Torque (Gland),  
200 Times Magnification



Omnisafe Anti Torque (Gland),  
1000 Times Magnification



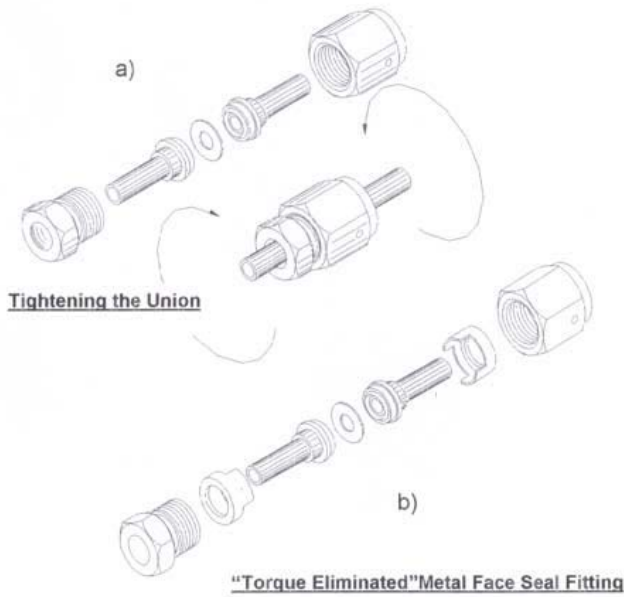
This is the cross sectional view of the Omnisafe fitting at finger tight. The gap between the torque eliminators is the same as the gasket thickness (.028"). If the gasket is missing, the torque eliminators bottom out into a "fail safe" mode. This prevents torroid to torroid contact and destruction. The fitting cannot pass leak check with the gasket missing.

The legacy metal face seal fitting, if tightened without a gasket, will crush both torroids. The only remedy for this is to replace both glands. Cutting off and rewelding new glands is a particle generating, time consuming, and expensive remediation operation.

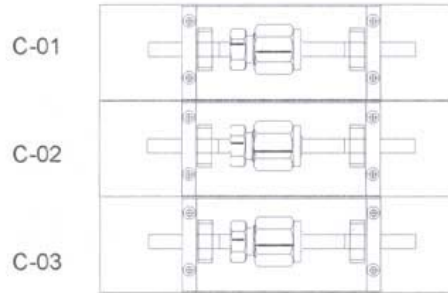
Tightening a legacy fitting without a gasket may even seal and give a false positive leak check reading. If a gas system is certified in this manner it may later develop a leak due to the damaged torroids. A leak that initiates when process gases are present is a much more dangerous situation especially if the gases are corrosive, toxic or pyrophoric.



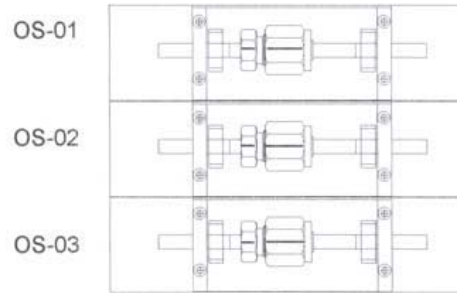
"Standard" Metal Face Seal Fitting



Standard Metal Face Seal Fittings



Torque Eliminated  
Metal Face Seal Fittings



c)

Figure 1. a) "Standard" metal face seal fitting; b) "Torque Eliminated" metal face seal fitting; c) Fixtured components after shock test;

**Mil Std 810E is designed to check the seal integrity of equipment under transportation shock & vibration. This study was performed by Applied Materials at Quanta Labs . The vibration phase was conducted for 3 hours which is designed to simulate 3000 miles of transportation.**

**The fittings glands were clamped into the fixture before tighten to simulate components that are attached to the back panel in a gas box.**

## Mil Std-810E Transportation Vibration

All equipment shipped as secured cargo by land, sea or air will experience this environment.

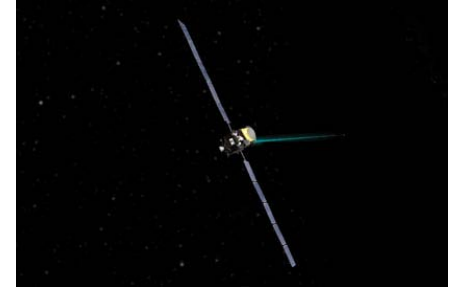
Mil Std-810E	Base Leak Rate (atm cc/sec He)	Post Vibration #1 (vertical 1.04g) 3 hr	Post Vibration #2 (transverse 0.2g) 3 hr	Post Vibration #3 (axial 0.74g) 3 hr	Post Shock #4 (vertical 40g) 11 msec	Post Vibration #5 (axial 0.74g) 3 hr	Post Vibration #6 (transverse 0.2g) 3 hr	Post Vibration #7 (vertical 1.04g) 3 hr
Std Metal Face Seal Fitting C-01	$1 \times 10^{-9}$	$1 \times 10^{-9}$	$1 \times 10^{-9}$	$1 \times 10^{-9}$	$1 \times 10^{-9}$	$1 \times 10^{-9}$	$1 \times 10^{-9}$	$1 \times 10^{-9}$
Std Metal Face Seal Fitting C-02	$1 \times 10^{-9}$	$1 \times 10^{-9}$	$1 \times 10^{-9}$	$1 \times 10^{-9}$	$1.02 \times 10^{-7}$	$1.02 \times 10^{-7}$	$9.84 \times 10^{-6}$	$9.84 \times 10^{-6}$
Std Metal Face Seal Fitting C-03	$1 \times 10^{-9}$	$1 \times 10^{-9}$	$1 \times 10^{-9}$	$1 \times 10^{-9}$	$1 \times 10^{-9}$	$1 \times 10^{-9}$	$3.23 \times 10^{-9}$	$3.23 \times 10^{-9}$
Omnisafe TS MFS Fitting OS-01	$1 \times 10^{-9}$	$1 \times 10^{-9}$	$1 \times 10^{-9}$	$1 \times 10^{-9}$	$1 \times 10^{-9}$	$1 \times 10^{-9}$	$1 \times 10^{-9}$	$1 \times 10^{-9}$
Omnisafe TS MFS Fitting OS-02	$1 \times 10^{-9}$	$1 \times 10^{-9}$	$1 \times 10^{-9}$	$1 \times 10^{-9}$	$1 \times 10^{-9}$	$1 \times 10^{-9}$	$1 \times 10^{-9}$	$1 \times 10^{-9}$
Omnisafe TS MFS Fitting OS-03	$1 \times 10^{-9}$	$1 \times 10^{-9}$	$1 \times 10^{-9}$	$1 \times 10^{-9}$	$1 \times 10^{-9}$	$1 \times 10^{-9}$	$1 \times 10^{-9}$	$1 \times 10^{-9}$

Visible loosening of the male and female nut

Gas stick no longer passes  $1 \times 10^{-9}$  leak check

The results of this test show that all three legacy face seal fittings show a noticeable loosening of the male/female nut post shock phase. One fitting no longer passes leak check  $10^{-9}$ . After the final three axis vibration the first leak gets worse and a second fitting fails leak check. The Omnisafe fittings show no loosening or leak. Since this test Omnisafe fittings have been flight qualified by JPL/NASA and Boeing.

# Omnisafe Flight Qualification



Omnisafe works better than any other fitting for semiconductor applications and has been flight qualified and selected for the following aerospace programs.

- JPL DAWN, Xenon Ion Propulsion, Asteroid Belt, May 2007, Omnisafe 1/8" fittings
- MSL Mars rover, launch 2009, for the liquid Freon heat rejection system, Omnisafe 3/8" fittings.
- NASA Evolutionary Xenon Thruster (NEXT) program. Xenon Ion Propulsion, Omnisafe 1/8" fittings
- Boeing Satellite Systems for Xenon Ion Propulsion, orbit maintenance, Omnisafe 1/8" fittings.

## JPL Flight Test Qualification

<u>Parameter</u>	<u>Test Data</u>
Proof Test	300 psig
Leak Check	1.0 E-7 sccs/sec
Mate/Demate	10 times
Random Vibe Test	
20Hz.....	0.024 g <sup>2</sup> /Hz
50-500 Hz...	0.06 g <sup>2</sup> /Hz
2000 Hz.....	0.015 g <sup>2</sup> /Hz
Pyroshock Test	
100 Hz .....	20 g's
1600 Hz ...	2000 g's
2500 Hz....	2000 g's
Thermal Cycling	-115 C to +145 C
Burst Test	2200 psig

June 14, 2012



# Metal Face Seal Fitting, [Field Study] Multi Mate-Demate Record

This report details a Multi mate/demate field study at Lawrence Livermore National Laboratory. **Over six years in service**, this fitting was **mate/demated 1557** times and was still working effectively when decommissioned. This evaluation shows the direct cost savings by avoiding the replacement of fittings that no longer passed leak check in this crystal growth equipment. The opportunity cost of having the system down for maintenance in a production environment is a much greater cost. The system maintenance hours avoided are tabulated below.

The Omnisafe fitting mounted on a **Crystal Growth Chamber** was exposed to hot (200C) hydrogen fluoride gas for a four hour run daily, for six years without a single failure. The fitting was mate/demated once per day.

Standard 1/2" metal face seal fittings without torque elimination typically lasted 15 mate/demate cycles (three weeks) in this environment.

Over the system life (311 weeks) in this case, LLNL avoided approximately 103 fitting replacement, maintenance events.

In quantities of 100 the material cost for standard 1/2" fittings is estimated at  $\$36.75 * 100 = \$3,675$

The labor included prepping the system, cutting off the old glands, decontaminating the old parts, prepping the ends, orbitally welding on new glands, and leak checking the system. The whole process took 4-6 hours. The labor cost was \$500 approximately plus the decontamination cost.

Total direct cost per maintenance event **\$536.**

Total direct cost savings **annually** was **\$8,933.**

Total direct cost savings **over the system life** **\$53,600.**

The value added in increased system availability was **83** hours **annually.**

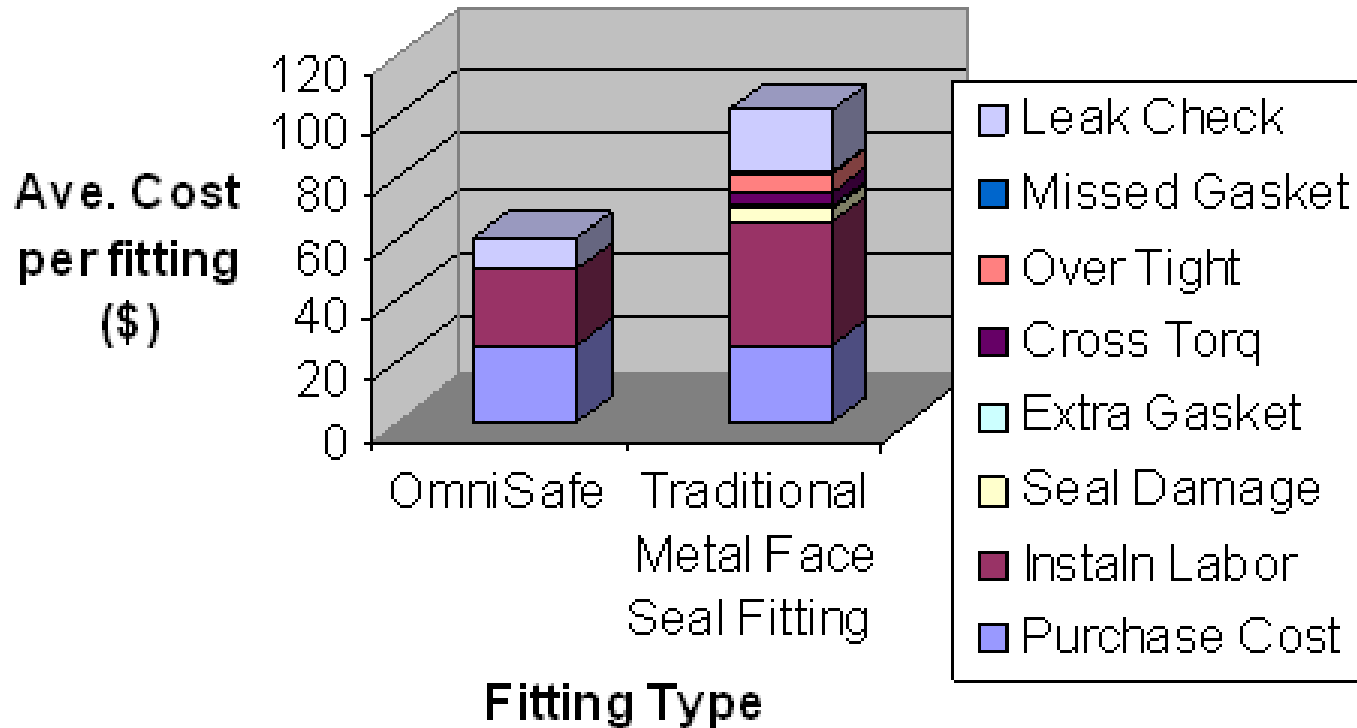
The additional production time made available was **498** hours **over the system life**, when considering the maintenance events that were avoided.

**Conclusion** - in terms of sealing surface preservation and the ability to pass leak check, this field test showed the Omnisafe fitting was **over 100 times better** than the legacy metal face seal fitting. In truth, since there is no galling during Omnisafe seal formation, the torroidal seal may last indefinitely. The **\$53,600** savings is a very conservative number since it does not include the production opportunity gained by avoiding maintenance. If the opportunity cost is \$40K per 8 hr shift in a semiconductor fab then this fitting's longevity would have saved **over \$19M** in avoided down-time cost over 6 years. Pareto analysis of fitting failures in the industry would indicate that 95% of the cases involve problems with the sealing surfaces. Omnisafe enables gas system engineers to avoid these fitting failures. This represents significant cost reduction.

# Fighting Torque, mitigation and minimization

- “**Tribology** is the science and technology of [friction](#), [lubrication](#), and [wear](#). Formally defined, it is the science and technology of interacting surfaces in relative motion.
- In non-torque eliminated fittings designers are fighting physics, working with a second best product with a fundamental design flaw.
- Instead of enabling this less than optimal product, “Eliminate the torque” to increase component life, reduce down time, reduce cycle time, and increase yield.

# Total Fitting Cost in an Assembly



This graph shows the installed cost of an Omnisafe vs the legacy metal face seal fitting. For either fitting the purchase price is \$20-30 based on quantity. The additional labor cost of legacy fittings occur while trying to keep the components in alignment, undamaged, and leak tight during gas system assembly. Cost avoidance due to torque elimination results in significant savings. The installed cost for Omnisafe fittings is \$55 vs \$95 for a legacy fitting. From this point on the Omnisafe fitting continues to reduce maintenance cost and extend component life for the life of the gas system.

# References

1. The rotation, particle study, EDS and S.E.M.s are from Unit Instruments and Lam Research. [Solid State Technology April 1997](#)
2. The Vib and Shock 810E came from Applied Materials and Quanta Labs in Sunnyvale. [Torque Elimination Fittings Add to Gas Handling Safety 2002](#)
3. The multi mate/demate testing was done at Lawrence Livermore National Labs [MDS - Material Performance, September 1999](#)
4. For flight qualification data - [Flight Qualification of Omnisafe Anti-Torque, MultiMate/Demate Fitting – Joint Propulsion Conference 2005](#)

These research papers are available at ...[www.omnisafe.net](http://www.omnisafe.net) under [PUBLICATIONS](#)